Diabetes Prevalence by Leisure-, Transportation-, and Occupation-Based Physical Activity Among Racially/Ethnically Diverse U.S. Adults

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EPIDEMIOLOGY/HEALTH SERVICES RESEARCH

OBJECTIVE

Leisure-time physical activity (LTPA) has been shown to prevent or delay the development of diabetes. However, little research exists examining how other domains of PA (e.g., occupation based [OPA] and transportation based [TPA]) are associated with diabetes prevalence across diverse racial/ethnic groups. We examined associations between OPA, TPA, and LTPA and diabetes prevalence and whether associations differed by race/ethnicity.

RESEARCH DESIGN AND METHODS

Participants in the 2011–2016 National Health and Nutrition Examination Survey (NHANES) self-reported domain-specific PA. Diabetes status was determined by self-reported doctor/health professional–diagnosis of diabetes or a glycosylated hemoglobin (HbA_{1c}) measurement of ≥6.5% (48 mmol/mol). Multivariable log binomial models examined differences in diabetes prevalence by PA level in each domain and total PA among Latinos (*n* = 3,931), non-Latino whites (*n* = 6,079), and non-Latino blacks (*n* = 3,659).

RESULTS

Whites reported the highest prevalence of achieving PA guidelines (64.9%), followed by Latinos (61.6%) and non-Latino blacks (60.9%; $P < 0.0009$). Participants achieving PA guidelines were 19–32% less likely to have diabetes depending on PA domain in adjusted models. Diabetes prevalence was consistently higher among non-Latino blacks (17.1%) and Latinos (14.1%) compared with non-Latino whites (10.7%; $P < 0.0001$), but interaction results showed the protective effect of PA was similar across PA domain and race/ethnicity—except within TPA, where the protective effect was 4% greater among non-Latino whites compared with Latinos (adjusted difference in risk differences 0.04, $P = 0.01$).

CONCLUSIONS

PA policies and programs, beyond LTPA, can be leveraged to reduce diabetes prevalence among all population groups. Future studies are needed to confirm potentially differential effects of transportation-based active living on diabetes prevalence across race/ethnicity.

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Diabetes is one of the seven leading controllable risk factors for cardiovascular disease in the U.S. Recent surveillance data indicate a prevalence of 9.4% for the U.S. population overall, with substantial disparities observed by race/ethnicity, including a faster increase in diabetes incidence for Latino and non-Latino black adults compared with non-Latino white adults over the past 20 years (1,2). Research has consistently demonstrated that adoption of physical activity (PA) can prevent or delay the onset of type 2 diabetes (3,4) and lifestyle interventions that include PA can be more effective in diabetes prevention than the leading prescription drug metformin (5). Based on this evidence, a recent position statement from the American Diabetes Association recommends 150 min/week of moderate to vigorous PA to help prevent or delay the onset of type 2 diabetes (6), which is also consistent with the recommendations of the 2018 Physical Activity Guidelines for Americans (7).

While studies have demonstrated that more active living can reduce diabetes risk (3,4), most of this research has focused on leisure-time PA (LTPA) (3). Little empirical evidence exists investigating whether the same health-enhancing effects are observed across domains (i.e., types) of PA. A recent systematic review by Aune et al. (3) of 81 cohort and controlled trial studies found that 63% of these studies investigated the effect of LTPA on type 2 diabetes. The authors found only three studies investigating the effect of occupational PA (OPA) on diabetes risk, all of which reported varying results (3). Further, meta-analyses and narrative reviews suggest differential effects of PA on diabetes prevalence by race/ethnicity, indicating that most racial/ethnic groups benefit from PA, except among non-Latino blacks, where no significant protective effect has been observed (8,9).

The current study responds to this knowledge gap by investigating how domain of PA—namely, LTPA, OPA, TPA, and total PA—are associated with diabetes prevalence among Latino, non-Latino black, and non-Latino white adults in a population-based sample. We hypothesized that diabetes prevalence would differ across each domain of PA but we would observe higher diabetes prevalence among those not achieving PA guidelines. We also examined whether the association between LTPA, OPA, and TPA and diabetes differs by race/ethnicity, hypothesizing that associations would be less consistent in racially/ethnically diverse population groups.

RESEARCH DESIGN AND METHODS

Study Sample

The study population included nonpregnant adults (20 years of age or older) from three cross-sectional waves of the Centers for Disease Control and Prevention's National Health and Nutrition Examination Survey (NHANES): 2011–2012, 2013–2014, and 2015–2016. Participants in NHANES were surveyed on topics related to health as well as demographic, socioeconomic, and dietary topics. NHANES uses a complex, multistage stratified probability cluster sample design, which results in a representative sample of the noninstitutionalized U.S. civilian population. Additional details on the NHANES survey, sampling methodologies, and design have previously been published (10).

Measures

Diabetes

Diabetes diagnosis was defined by *1*) participant self-report (being told by a doctor or health professional that you have diabetes or sugar diabetes) or *2*) blood glycoslyated hemoglobin (HbA_{1c}) measurement of 6.5% (48 mmol/mol) or greater following accepted thresholds for diabetes diagnosis in adults (11), measured during the study visit. Previous research using cohort data has demonstrated that self-reported diabetes diagnosis is valid and reliable compared with HbA_{1c} data (12). A dichotomous diabetes diagnosis variable was used for analyses.

PA

PA was self-reported by participants using the Global Physical Activity Questionnaire (13). Measures of PA were calculated corresponding to three common areas of PA participation: OPA, TPA, and LTPA. OPA includes all work-related PA such as household chores and construction work. Likewise, bicycling and walking for transportation are counted under TPA. Sports, fitness, and other recreational activities are included as LTPA. Additionally, a total PA score was calculated by summing minutes across the three domains of PA.

Participants reported the frequency, intensity, and amount of time spent in PA in a typical week. Participants were asked to report on vigorous and moderate forms of PA done while working (OPA) and for leisure (LTPA). For OPA or LTPA, minutes of vigorous PA were doubled and added to minutes of moderate PA. This was then multiplied by number of days of activity to obtain the total minutes of PA spent in a typical week (7). As a population-based survey, NHANES does not collect data on every type of activity participants engage in, and thus the doubling of vigorous PA and adding moderate activity represents an approximation of energy expenditure across the range of activities most U.S. adults report. This approach is also consistent with the 2011 Compendium of Physical Activities (14) and the NHANES Codebook (15) assigning vigorous activity a MET value that is approximately double that of moderate PA (14,16). The summed minutes of PA were further dichotomized into *1*) 150 min or more (i.e., achieved guidelines for PA) or *2*) 0–149 min (i.e., did not achieve guidelines for PA) following the 2018 Physical Activity Guidelines Advisory Committee Scientific Report (16) and derived separately for LTPA, TPA, OPA, and total PA.

Race/Ethnicity

Race/ethnicity was self-reported by participants. Latinos self-identified as Latino irrespective of race. Non-Latino black and non-Latino white participants self-identified as such but did not indicate Latino ethnicity.

Other Covariates

Other covariates included sociodemographic variables such as age (20–39 years old, 40–59 years old, 60–79 years old, and 80 years of age or older), sex (male or female), marital status (married or unmarried), education (less than a high school degree, high school degree or equivalent, some college, and 4 year college degree or more), annual household income (less than $25,000, between $25,000 and $74,999, and $75,000 or more), and health insurance coverage (covered or not covered by public or private health insurance). Additionally, we controlled for BMI because it is a strong predictor of diabetes, although BMI is conceptually a mediator between PA and diabetes. BMI was based on measured height and weight (weight

Table 1—Sample characteristics (adults aged ≥20 years) by race/ethnicity: NHANES, 2011–2016

		Race/ethnicity			
	All (13,669)*	Latino, 16.1 (3,931)	Non-Latino white, 71.5 (6,079)	Non-Latino black, 12.4 (3,659)	P†
Age (years)					<0.0001
20–39	34.9 (4,426)	49.6 (1,352)	30.8 (1,905)	39.6 (1,169)	
40–59	37.4 (4,537)	35.6 (1,342)	37.5 (1,892)	38.8 (1,303)	
60–79	22.9 (3,777)	13.3 (1,131)	25.7 (1,585)	19.1 (1,061)	
≥80	4.8 (929)	1.5 (106)	6.0 (697)	2.5 (126)	
Sex					<0.0001
Male	48.6 (6,652)	50.4 (1,854)	48.8 (3,021)	45.3 (1,777)	
Female	51.4 (7,017)	49.6 (2,077)	51.1 (3,058)	54.7 (1,882)	
Education					<0.0001
Less than high school	15.7 (3,348)	40.5 (1,729)	9.7 (860)	18.7 (759)	
High school	21.5 (3,143)	21.4 (811)	20.7 (1,359)	25.8 (973)	
Some college	32.7 (4,248)	25.6 (932)	33.7 (2,070)	36.1 (1,246)	
College degree or more	30.1 (2,918)	12.5 (456)	35.9 (1,789)	19.4 (673)	
Income					<0.0001
0–$24,999	20.8 (4,114)	32.0 (1,251)	16.4 (1,677)	33.4 (1,186)	
$25,000–$74,999	42.6 (5,670)	48.9 (1,715)	40.8 (2,389)	45.7 (1,566)	
≥$75,000	36.5 (3,186)	19.1 (645)	42.9 (1,835)	20.9 (706)	
Health insurance: yes	82.9 (10,743)	60.0 (2,585)	88.9 (5,220)	78.4 (2,938)	
Married: yes	53.7 (6,567)	51.1 (2,075)	57.9 (3,228)	32.5 (1,264)	<0.0001
BMI (kg/m^2)					<0.0001
Low to normal (<25)	27.8 (3,444)	21.2 (776)	29.9 (1,804)	24.1 (864)	
Overweight (25–29.99)	33.2 (4,400)	34.9 (1,379)	33.7 (1,983)	28.2 (1,038)	
Obese (≥30)	39.0 (5,638)	43.9 (1,729)	36.4 (2,206)	47.7 (1,703)	
OPA: achieved recommendation††	35.6 (4,502)	35.9 (1,264)	36.2 (2,146)	31.7 (1,092)	<0.001
LTPA: achieved recommendation††	38.3 (4,521)	33.2 (1,161)	40.0 (2,144)	35.2 (1,216)	<0.0001
TPA: achieved recommendation††	13.1 (1,900)	15.3 (592)	12.2 (724)	15.7 (584)	<0.02
Total PA: achieved recommendation††	63.9 (8,116)	61.6 (2,252)	64.9 (3,713)	60.9 (2,151)	<0.0009
Diabetes: yes	12.1 (2,297)	14.1 (1,773)	10.7 (782)	17.1 (742)	<0.0001

Data are (*n*) or % (*n*). *Due to missing data, the *n* and % values may not add to total sample size. †Wald χ^2 test for independence. ††Achieved the PA recommendation (≥150 min/week of moderate to vigorous activity) through this domain of PA alone (for OPA, LTPA, or TPA), and for all PA combined (for total PA).

in kilograms divided by the square of height in meters). Following established cutoffs, we categorized BMI as low to normal weight (<25 kg/m^2), overweight (25–29.99 kg/m^2), or obese (≥30 kg/m^2).

Statistical Analysis

Weighted percentages and unweighted counts for variables of interest were calculated for the combined 6-year survey period by race/ethnicity. Wald χ^2 tests were used to test for differences across race/ethnicity on sample characteristics. We ran two sets of multivariable log binomial models to estimate prevalence ratios (PRs) examining associations of achieving PA guidelines through LTPA, TPA, OPA, and total PA with prevalence of diabetes, with adjustment for theoretically and empirically informed covariates. After fitting log binomial models that generated predicted probabilities estimating diabetes prevalence, we tested for differences (i.e., an interaction) in diabetes prevalence by race/ethnicity. The first set of analyses pooled across race/ethnicity and included four models. Model 1 presents the unadjusted (crude) association of LTPA, TPA, OPA, and total PA with diabetes diagnosis. Model 2 adjusts for age and sex. Model 3 additionally adjusts for education, income, marital status, and health insurance status. Finally, model 4 additionally adjusts for BMI. In the second set of analyses, we examined heterogeneity in diabetes prevalence using predicted probabilities produced from models with a cross-product term between level of PA in each domain and race/ethnicity (adjusting for model 3 covariates) and graphically presented these estimates. We also calculated adjusted risk differences and conducted differences in risk difference tests to statistically compare the differences in prevalence at each level of PA. The analytic sample in the study includes adults who identified as Latino (*n* = 3,931), non-Latino white (*n* = 6,079), and non-Latino black (*n* = 3,659). Non-Latino Asians were excluded due to sample size constraints. All statistical tests were two sided and at the 5% significance level. Data were analyzed in SAS, version 9.4, and SAS callable SUDAAN, version 11.0.1, which uses Taylor series linearization to obtain SEs to account for the complex sampling design (17). This study was deemed exempt from institutional review board review.

RESULTS

Table 1 displays the sociodemographic characteristics of the study population by race/ethnicity. Almost half (49.6%) of Latinos were between age 20 and 39 years, while 39.6% of non-Latino blacks and 30.8% of non-Latino whites

Table 2—PR of diabetes prevalence by PA level and domain: adults aged ≥20 years, NHANES 2011–2016

	Model 1		Model 2		Model 3		Model 4	
	PR	95% CI	aPR	95% CI	aPR	95% CI	aPR	95% CI
OPA								
Achieved†	0.70	(0.62, 0.80)	0.83	(0.73, 0.95)	0.81	(0.71, 0.92)	0.84	(0.73, 0.96)
Did not achieve	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
LTPA								
Achieved†	0.49	(0.42, 0.56)	0.60	(0.52, 0.69)	0.71	(0.61, 0.82)	0.82	(0.71, 0.93)
Did not achieve	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
TPA								
Achieved†	0.62	(0.53, 0.73)	0.73	(0.62, 0.86)	0.69	(0.59, 0.81)	0.78	(0.66, 0.93)
Did not achieve	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent
Total PA								
Achieved†	0.50	(0.45, 0.57)	0.63	(0.56, 0.71)	0.68	(0.61, 0.77)	0.78	(0.69, 0.87)
Did not achieve	1.00	Referent	1.00	Referent	1.00	Referent	1.00	Referent

Model 1 was the crude model. Model 2 controlled for age and sex. Model 3 included the model 2 variables plus education, income, marital status, and health insurance status. Model 4 included the model 3 variables plus BMI. †Achieved the PA recommendation (≥150 min/week of moderate to vigorous activity) through this domain of PA.

fell in that age range. More than one-third (35.9%) of non-Latino whites were college educated compared with 19.4% of non-Latino blacks and 12.5% of Latinos. Non-Latino whites reported the highest prevalence of achieving national PA recommendations through any combination of PA (64.9%), followed by Latinos (61.6%) and non-Latino blacks (60.9%; $P < 0.0009$). Non-Latino whites reported achieving guidelines in the greatest proportion across all domains of PA, except TPA, where Latinos and non-Latino blacks reported a higher proportion achieving PA guidelines (15.3% and 15.7%) compared with whites (12.2%; $P < 0.02$). Non-Latino blacks had the highest proportion with a diabetes diagnosis (17.1%), followed by Latinos (14.1%) and non-Latino whites (10.7%; $P < 0.0001$).

Table 2 shows the results of multivariable regression models. In crude models (model 1), participants who achieved PA guidelines were 30–51% less likely to have a diabetes diagnosis than those who did not achieve PA guidelines, depending on the domain of PA. Across all domains of PA, the addition of age and sex reduced estimates substantively. In model 3, while the addition of income, education, marital status, and health insurance status did not fully explain any of the associations, the effect was reduced most notably within the LTPA domain between models 2 and 3 (adjusted PR [aPR] 0.60 [95% CI 0.52, 0.69] and aPR 0.71 [95% CI 0.61, 0.82], respectively). In model 3, with adjustment for all sociodemographic characteristics, TPA provided the greatest level of protection, while OPA provided the least. The addition of BMI as a covariate substantively reduced the effect estimates across all domains except within OPA, where the PR changed only slightly from 0.81 (95% CI 0.71, 0.92) to 0.84 (95% CI 0.73, 0.96). After adjustment for all covariates, including BMI, all domains of PA provided similar levels of protection against diabetes.

Figure 1 depicts the prevalence of diabetes across each domain of PA by race/ethnicity, with adjustment for age, sex, marital status, income, education, and health insurance. Across all domains of PA, there was a consistent pattern in which diabetes prevalence was higher among non-Latino blacks and Latinos, compared with non-Latino whites, who did not achieve PA requirements. Conversely, non-Latino whites were consistently less likely to have diabetes when they achieved PA guidelines across all domains of PA. In general, there was no statistically significant heterogeneity in prevalence reduction across PA levels by race/ethnicity within each domain, with the exception of TPA. Compared with Latinos, non-Latino whites who achieved PA guidelines through TPA had a significant reduction in diabetes prevalence (adjusted difference in risk differences = 0.04, P = 0.01). More specifically, in comparison of diabetes prevalence among those who achieved versus did not achieve PA guidelines through transportation, the estimates were 6% compared with 11% among non-Latino whites and 15% compared with 17% among Latinos.

CONCLUSIONS

This study investigated the association between achieving PA guidelines through various domains of PA and diabetes among a large nationally representative sample of Latinos, non-Latino blacks, and non-Latino whites. In models adjusting for sociodemographic factors, achieving PA guidelines through any domain of PA was protective against diabetes at levels comparable with estimates from other studies (3). Additionally, across all domains of PA, among those who did not achieve PA requirements, there was a consistent pattern in which diabetes prevalence was greatest among non-Latino blacks and Latinos and lowest in non-Latino whites. When comparing differences in prevalence estimates by achievement of PA guidelines, the reductions were similar for each racial/ethnic group across all domains except TPA, where the prevalence reduction was greater among non-Latino whites compared with Latinos.

Our findings were generally consistent with previous research indicating that engaging in more PA is associated with a lower prevalence of diabetes (3,6,18). However, prior research has been mostly limited to LTPA (3). Our study is one of the first to examine the relationship of other types of PA beyond LTPA with diabetes in a racially/ethnically diverse population-based study sample. In addition to recommended levels of LTPA being associated with a lower diabetes prevalence, our findings showed that individuals who achieve recommended levels of OPA, TPA, and total PA were

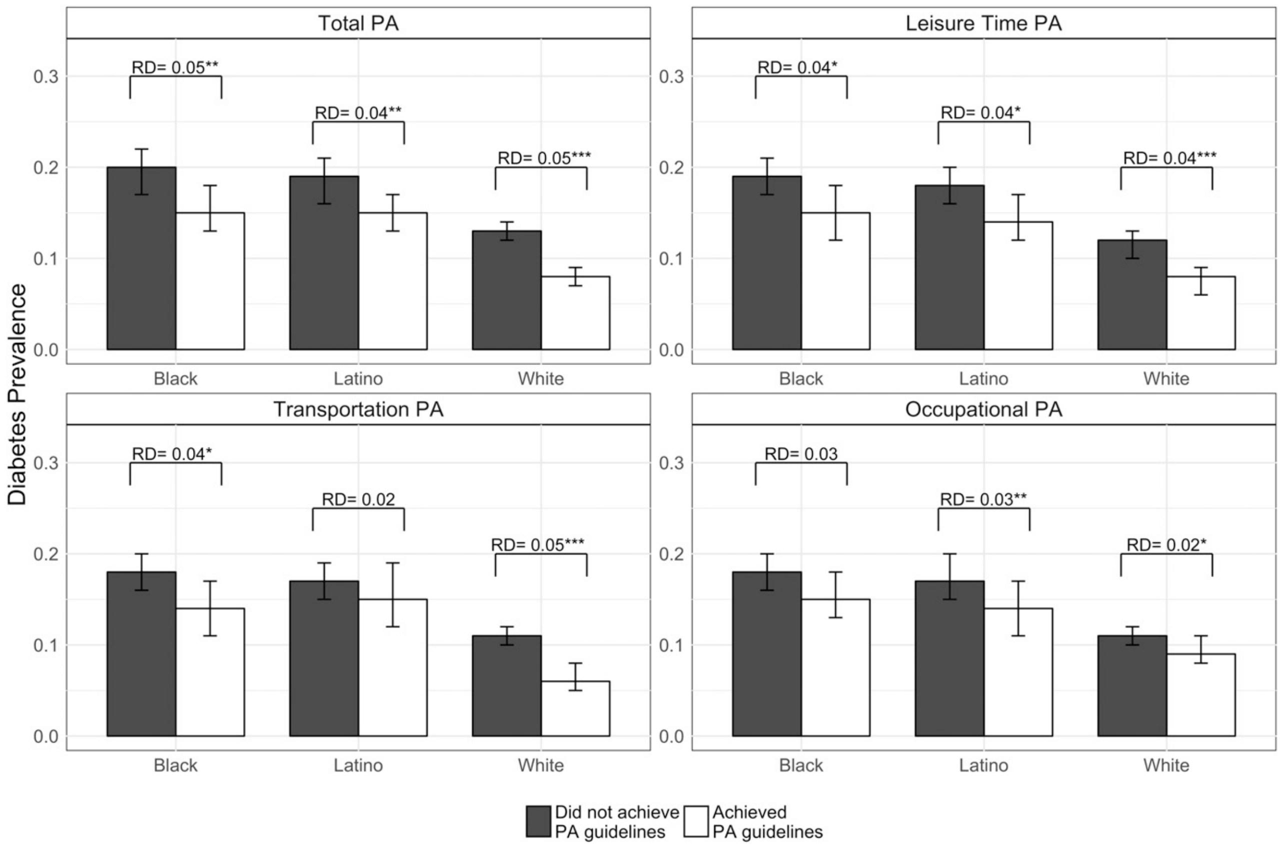

Figure 1—Prevalence of diabetes by domain, level of PA, and race/ethnicity, adjusted for age, sex, marital status, income, education, and health insurance. Asterisks (*) indicate the *P* value for the contrasted predicted marginal comparing diabetes prevalence among those achieving and not achieving guidelines within each domain. $*P < 0.05$; $**P < 0.01$; $***P < 0.001$.

significantly less likely to have diabetes than those who did not achieve guidelines. The protective effects were similar across all domains of PA. Notably, the addition of socioeconomic characteristics to the model reduced effect sizes most substantively within LTPA, suggesting that LTPA is highly influenced by socioeconomic determinants, consistent with previous literature (19,20). Thus, our findings highlight the importance of examining nonleisure activities to understand the potential etiologic role of PA on diabetes, especially given the racial/ethnic disparities observed by domain of PA (21,22).

Furthermore, because BMI is a strong predictor of diabetes, we included a model that additionally adjusted for BMI, finding that the addition of BMI reduced effect estimates across all domains of PA except OPA. These results support previous evidence that BMI may be a pathway through which PA affects diabetes risk (3); however, the patterning of BMI and socioeconomic determinants, such as occupation, differs by race/ethnicity (23). Exploring the risk factors in the pathway through which PA affects diabetes, particularly studies that explore differences by both race/ethnicity and domain of PA, may be useful in creating targeted diabetes risk reduction interventions.

One other study has shown that high levels of TPA are associated with lower odds of diabetes among adults (24). Our study expands this research by examining differences by race/ethnicity, finding that achieving PA guidelines corresponded to reductions in diabetes prevalence that were consistent across racial/ethnic groups and all activity domains except TPA. Specifically, the reduction in diabetes prevalence when achieving PA guidelines through transportation was greater among non-Latino white individuals compared with Latinos. These differences could be explained by factors not assessed in our study, such as neighborhood factors that facilitate TPA. For example, an abundant body of research has demonstrated that built environment and neighborhood characteristics influence PA, including TPA (25,26). However, Latinos are more likely to live in neighborhood/residential environments that are not conducive to active living (27). Therefore, future research is needed to examine how addressing disparities in neighborhood and built environment factors promotes PA adoption and subsequently reduces disparities in diabetes prevalence.

This study is not without limitations. The NHANES data used for our study are cross-sectional, which does not allow us to examine whether PA domain is prospectively associated with diabetes prevalence/incidence. There is also the potential for reverse causality. However, diabetes status is unlikely to lead to OPA given that this is predetermined by occupational status itself, and yet the association with diabetes was comparable for this domain with that of LTPA and TPA. We also relied on self-reported rather than objectively measured PA. Previous research has indicated that self-reported PA tends to differ from PA levels measured through accelerometers or other technologies (28,29). Given the focus on domain-specific PA, however, self-reported measures were appropriate for our study and provide a better assessment of TPA and OPA than device-measured PA, which may not be attributable to a specific activity. Another potential limitation of our study is the differences in self-report of PA by race/ethnicity (30). Our study was also limited by the inability to more accurately ascertain energy expenditure/MET minute values for PA within the previous week. Future studies that capture MET minutes to track volume of PA within diverse samples would further validate the findings of this study. Given our interest in PA domains, we did not examine associations between sedentary behaviors and diabetes prevalence. Future research should explore the role of sedentary behavior on diabetes outcomes independently and in combination with domain-specific PA. Lastly, in our study we were not able to assess the neighborhood or social environments that people live in, which affects their PA (e.g., presence of sidewalks, safety, neighborhood social cohesion) (25,26) and their risk for diabetes independent of PA (31).

In summary, we showed the importance of investigating the health effects of engaging in various domains of PA. We found no racial/ethnic differences in the benefits derived from achieving PA guidelines through each domain, except TPA and diabetes prevalence, although Latinos and non-Latino blacks had much higher diabetes prevalence relative to non-Latino whites. Public health initiatives are needed that support more active living in any domain, including TPA and the neighborhood contexts that facilitate this form of activity, for all population groups but particularly for Latino and non-Latino black populations at higher risk of diabetes. Future research is also needed that tests linkages between community-based programs and clinical care to support more active living in populations living with diabetes (32).

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Author Contributions. A.A.D. conceived of the final study design and analytic plan and led the writing of the manuscript. A.A.D., R.M., F.R., C.A.M., E.K.T., and S.E.E. critically revised the article for intellectual content and approved the version to be published. R.M. was responsible for interpretation of the findings and wrote substantial parts of the manuscript. C.A.M. assisted with data analysis and with the production of tables and figures. F.R. integrated clinical implications of the findings. E.K.T. addressed issues of interpretation on work-based PA. S.E.E. conceived of the study, supervised study implementation, and wrote substantial parts of the manuscript. A.A.D. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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